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[54] APPARATUS FOR MAKING MULTIPLE, COMPLEXLY PATTERNED EXTRUDATES

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 241,321, May 11, 1994.

[51] Int. Cl.⁶ B29C 47/10

[52] U.S. Cl. 425/382.4; 264/176.1; 264/211.14; 425/382 R; 425/464; 426/516; 426/517

[58] Field of Search 425/382 R, 382.2, 425/382.4, 464; 264/176.1, 209.8, 211.14; 138/45, 46; 251/120, 121, 122, 205, 251; 426/496, 516, 517

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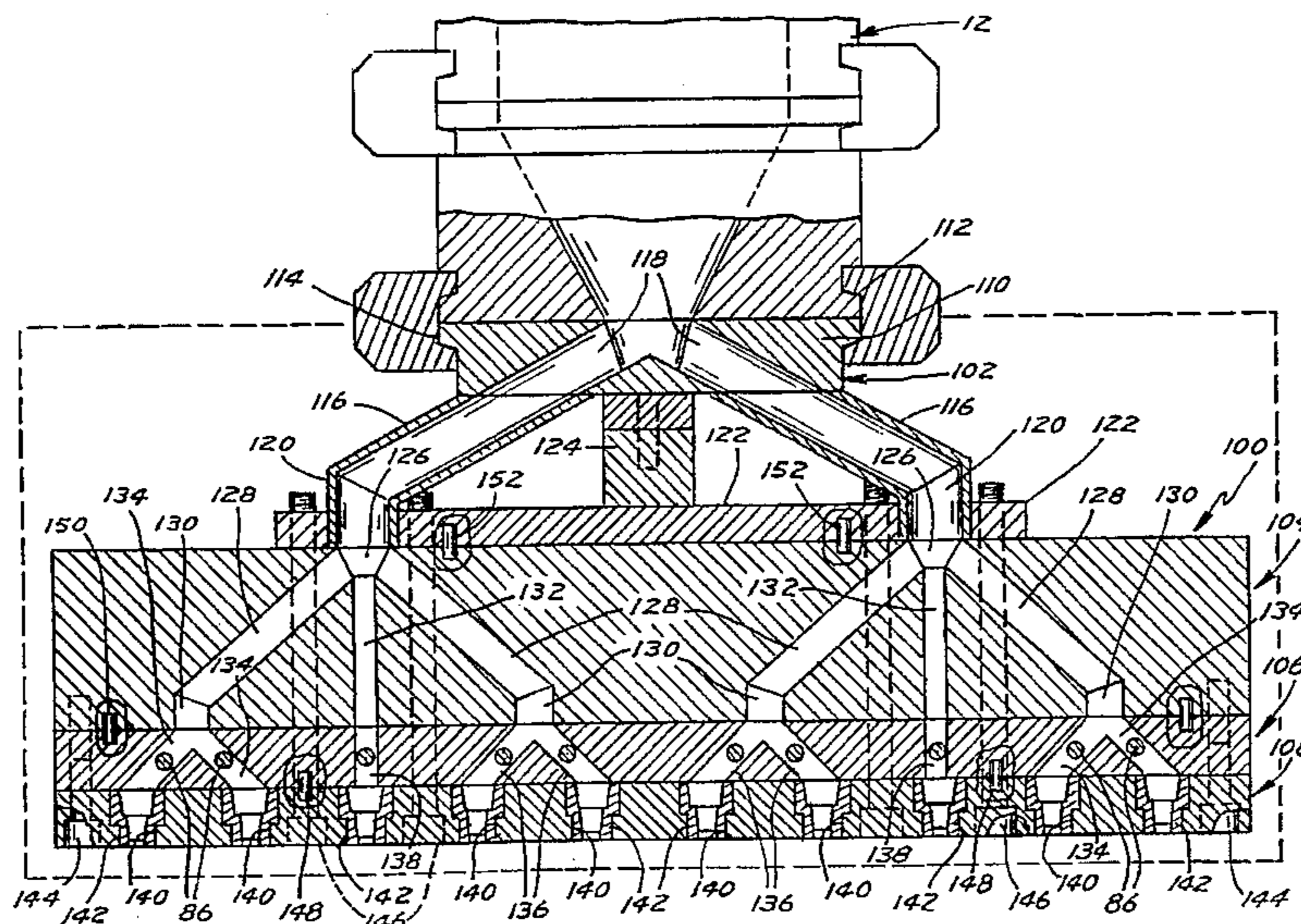
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[57] ABSTRACT

Apparatus (10) is disclosed where plastic extrudable food product is provided such as by a food cooker extruder (12) and is mixed with a food color to form a complexly patterned food product, such as by a pattern forming die (20). The cross-sectional area of the patterned food product is reduced from an inlet end (34) to an outlet end (36) by a factor of at least 50:1 at an average convergence angle of $\leq 45^\circ$ while maintaining the cross-sectional pattern to form a reduced cross-sectional patterned dough, and then is extruded through a die port having an opening equal to the reduced cross-sectional area to form a complexly patterned extrudate. In the preferred form, multiple extrudates are simultaneously formed with the flow rates for each extrudate being adjustable by an adjuster plug (16) including a smooth cylindrical portion (86) extendable into a passageway (14) having a circular cross section of a larger diameter than the cylindrical portion (86). In a preferred form, the extrudates are extruded in a non-circular pattern and specifically in a horizontal, single plane by a manifold (100) including ports (134, 136) and ducts (132, 138) receiving flow from passageways (128, 130) receiving flow from conduits (116, 118, 120) receiving flow from the food cooker extruder (12).

19 Claims, 6 Drawing Sheets



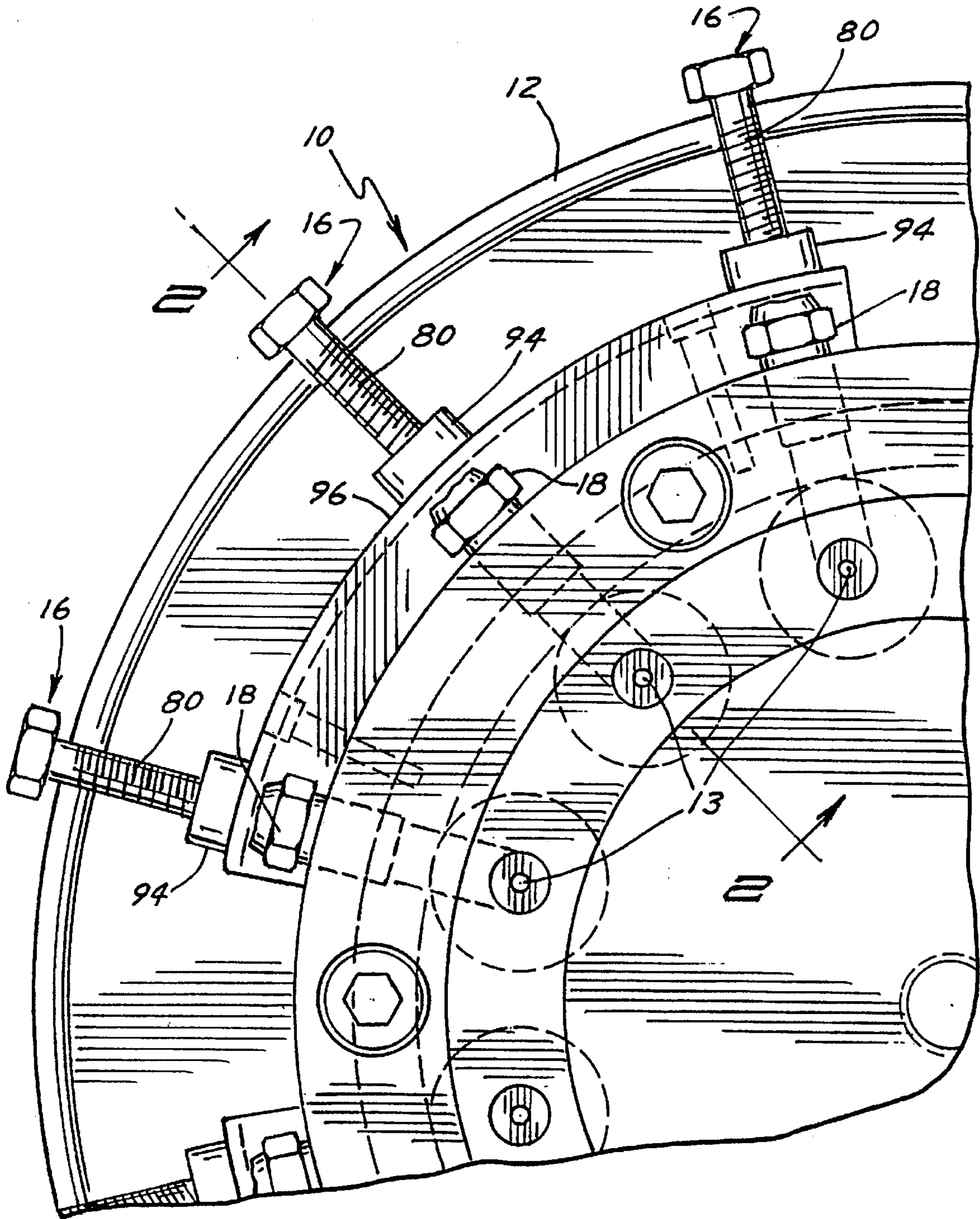
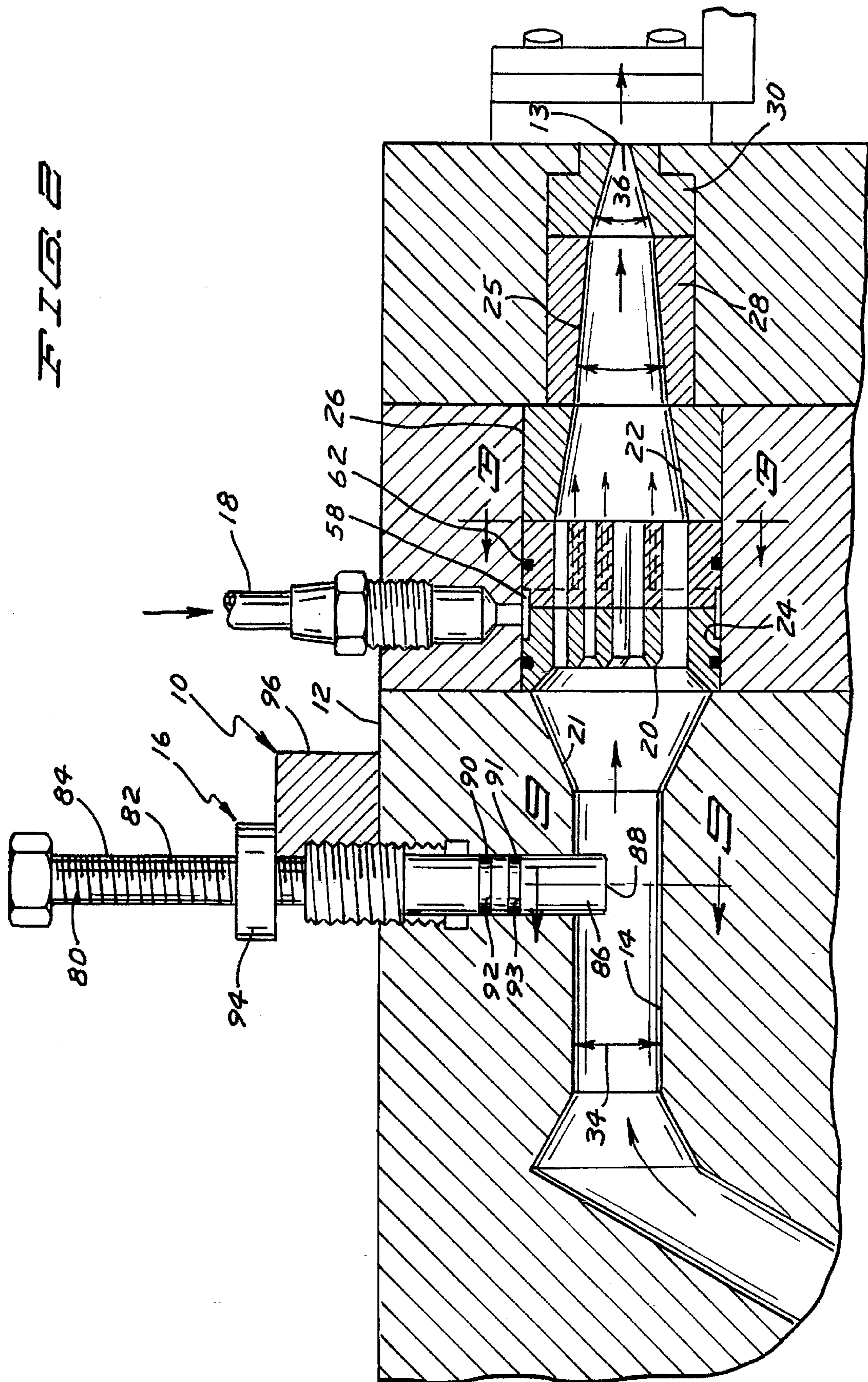


FIG. 1



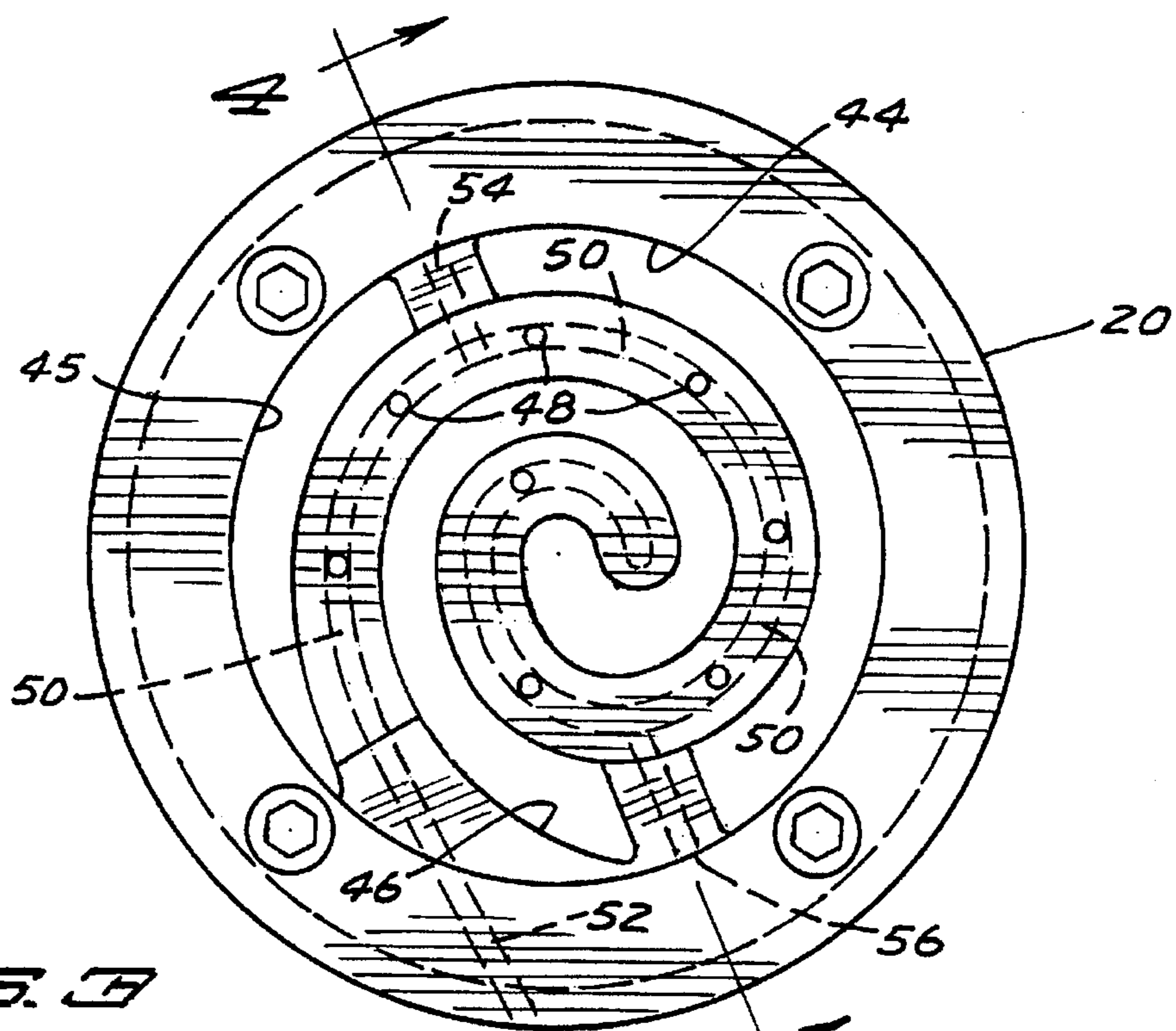


FIG. 3

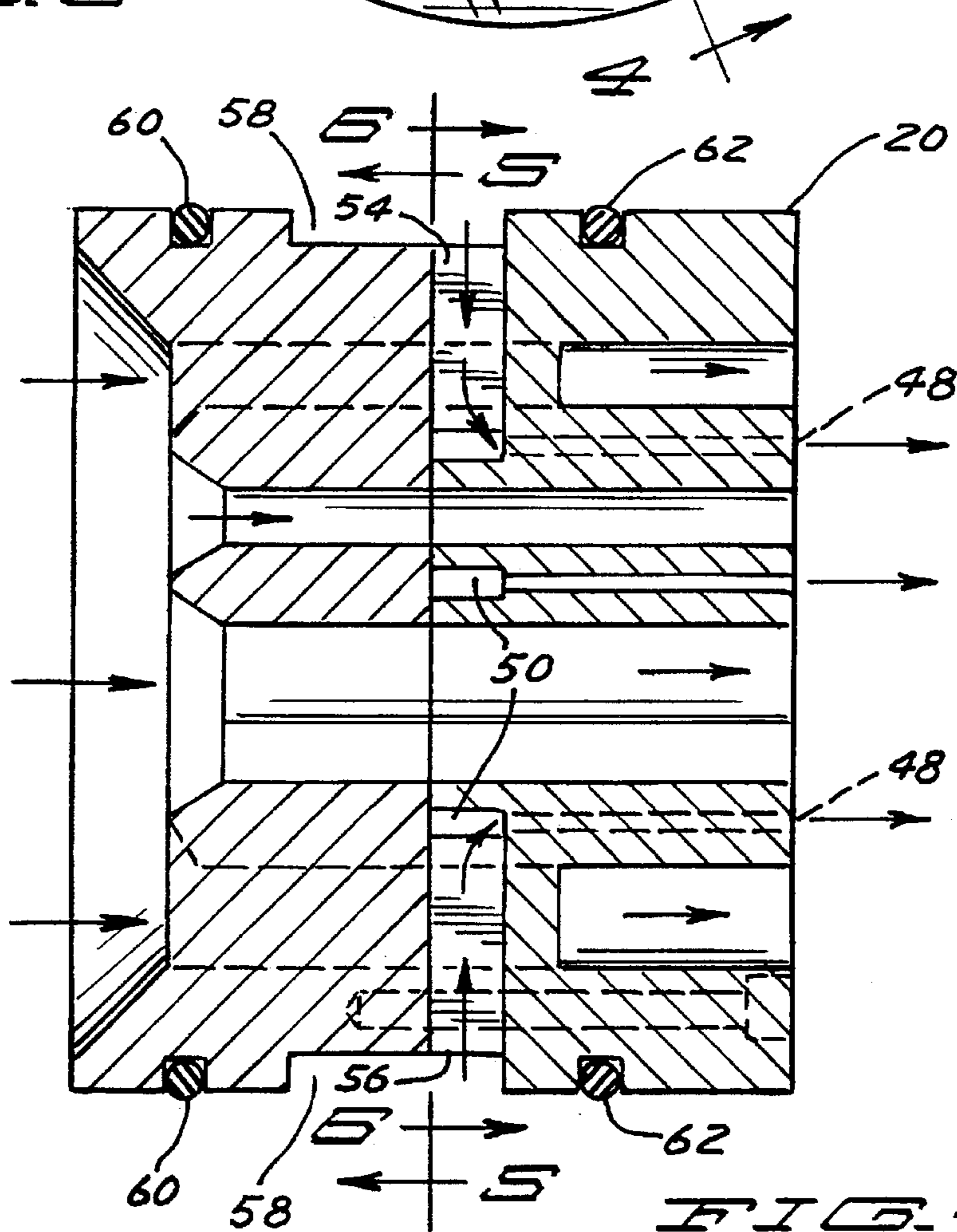
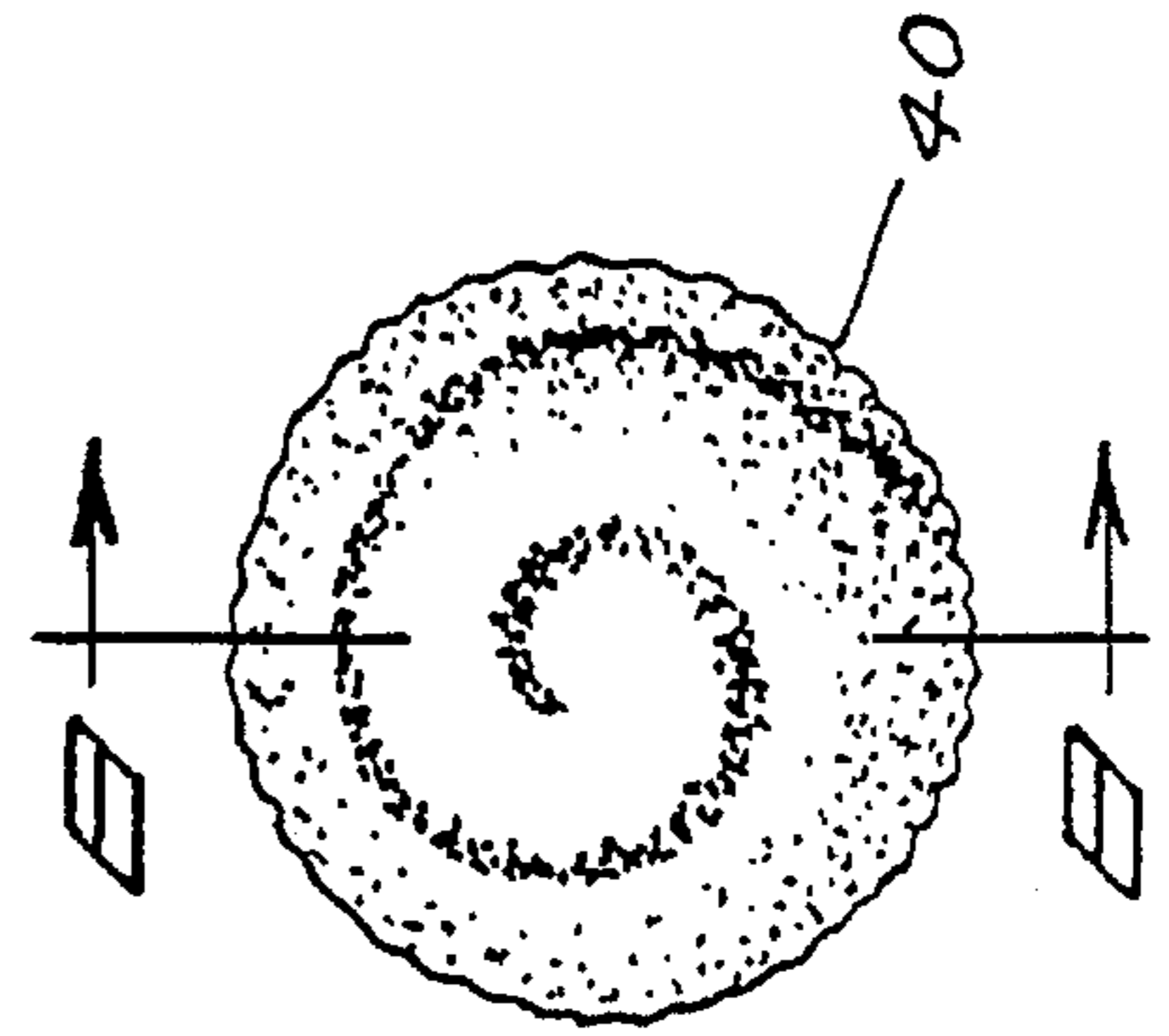
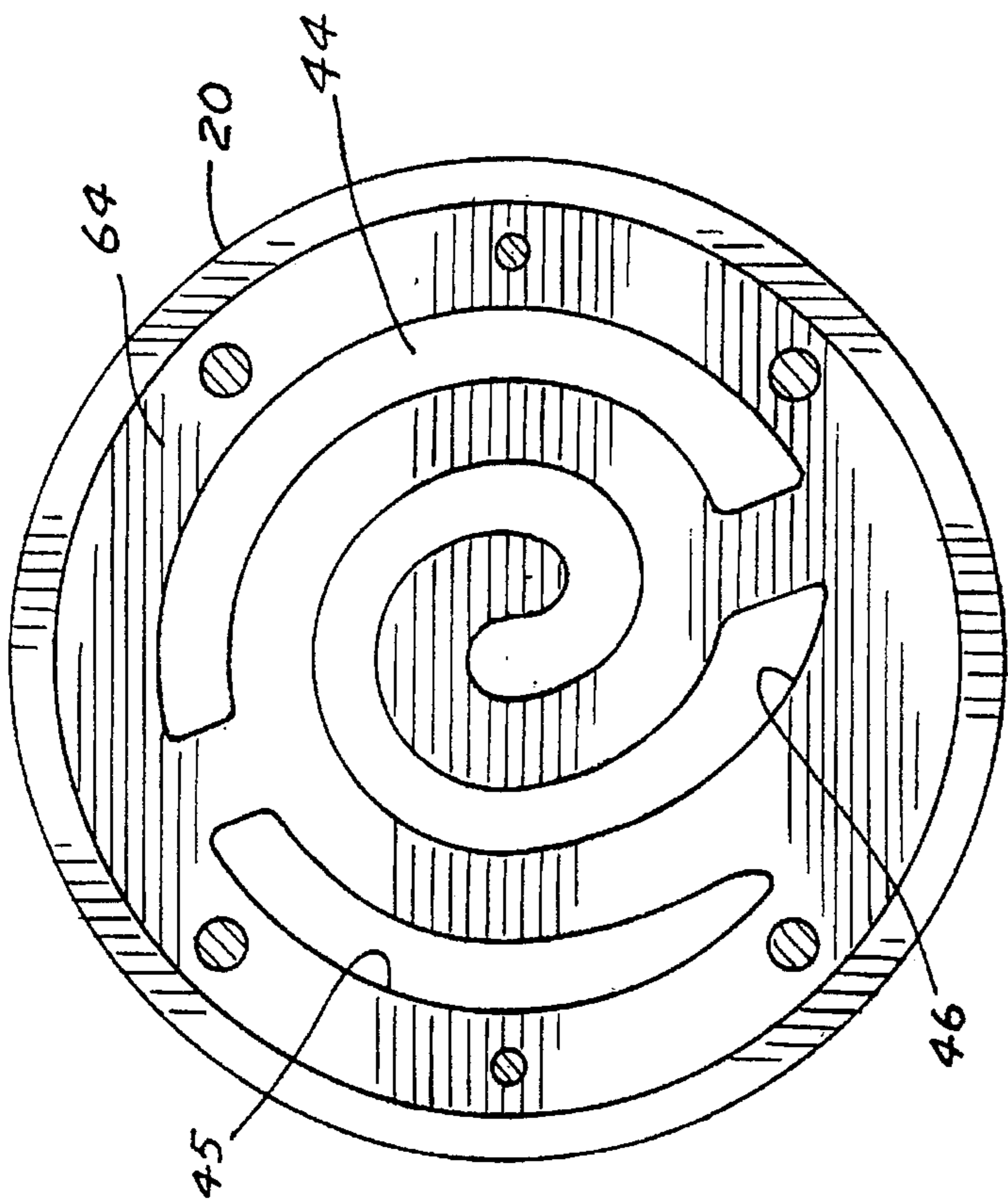
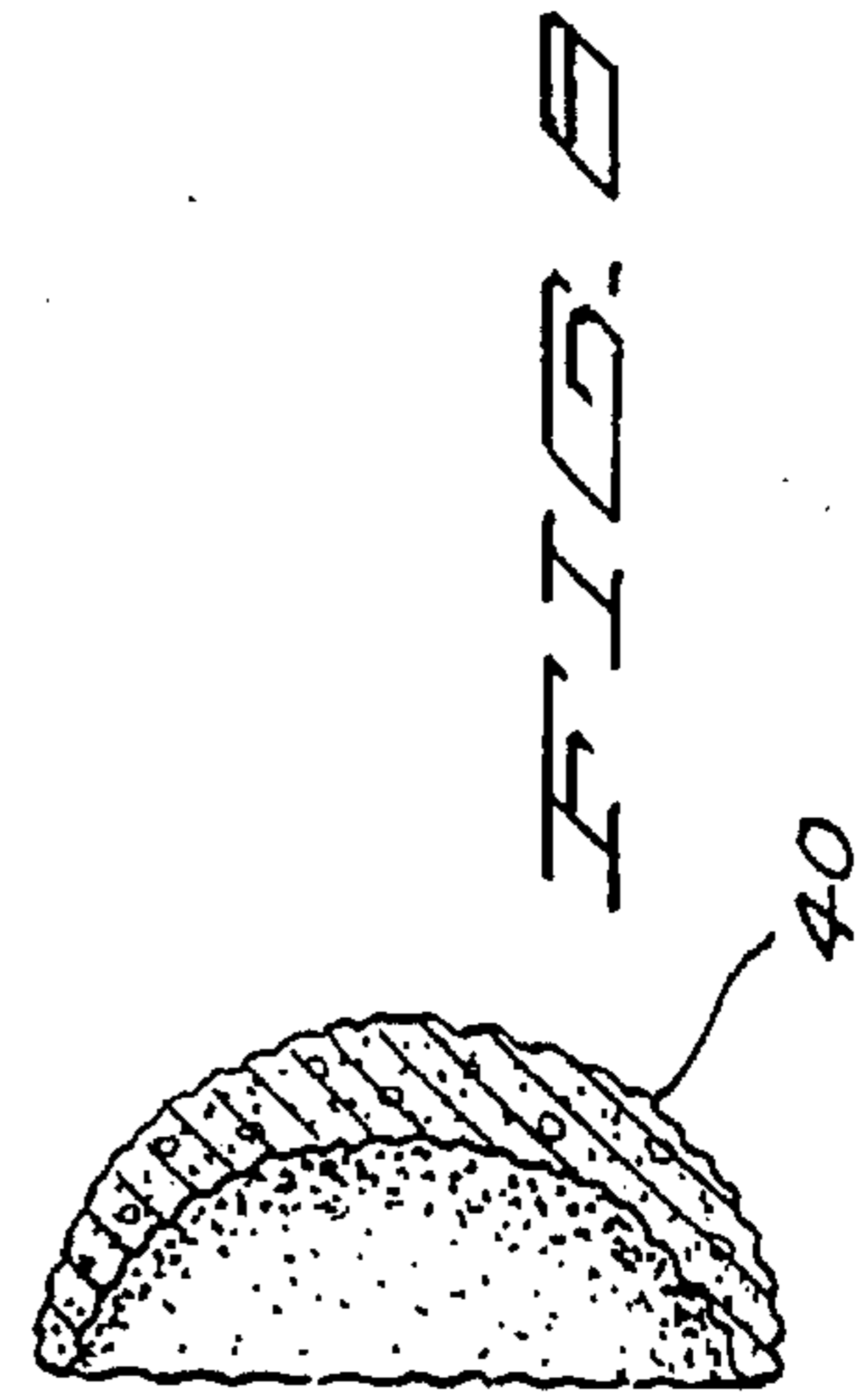
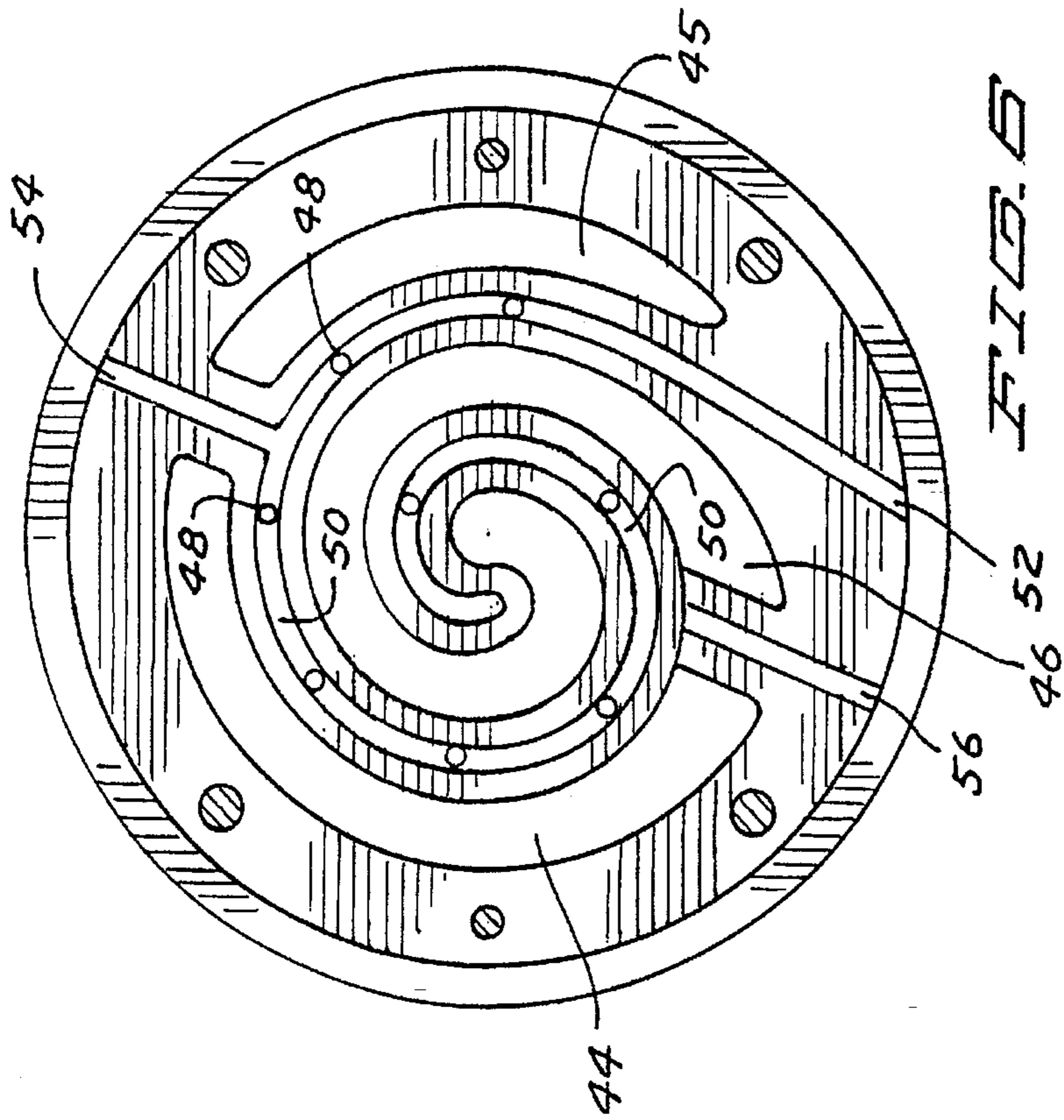
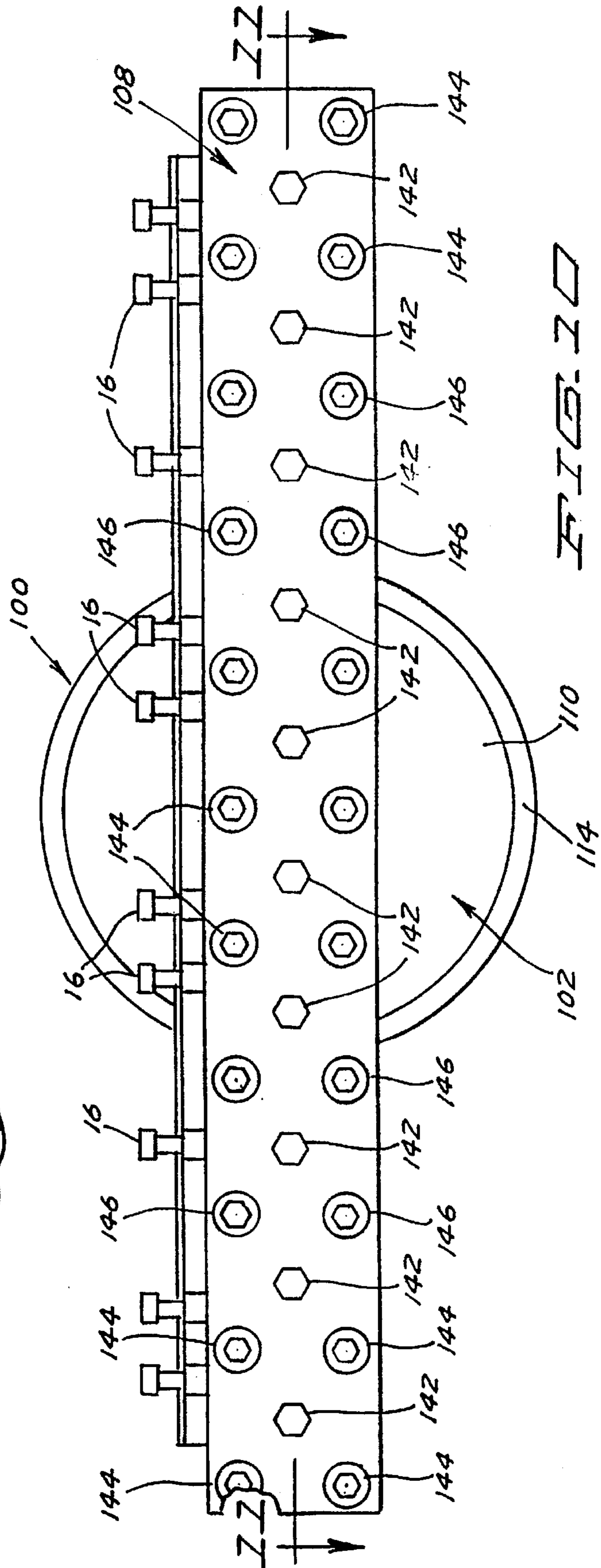
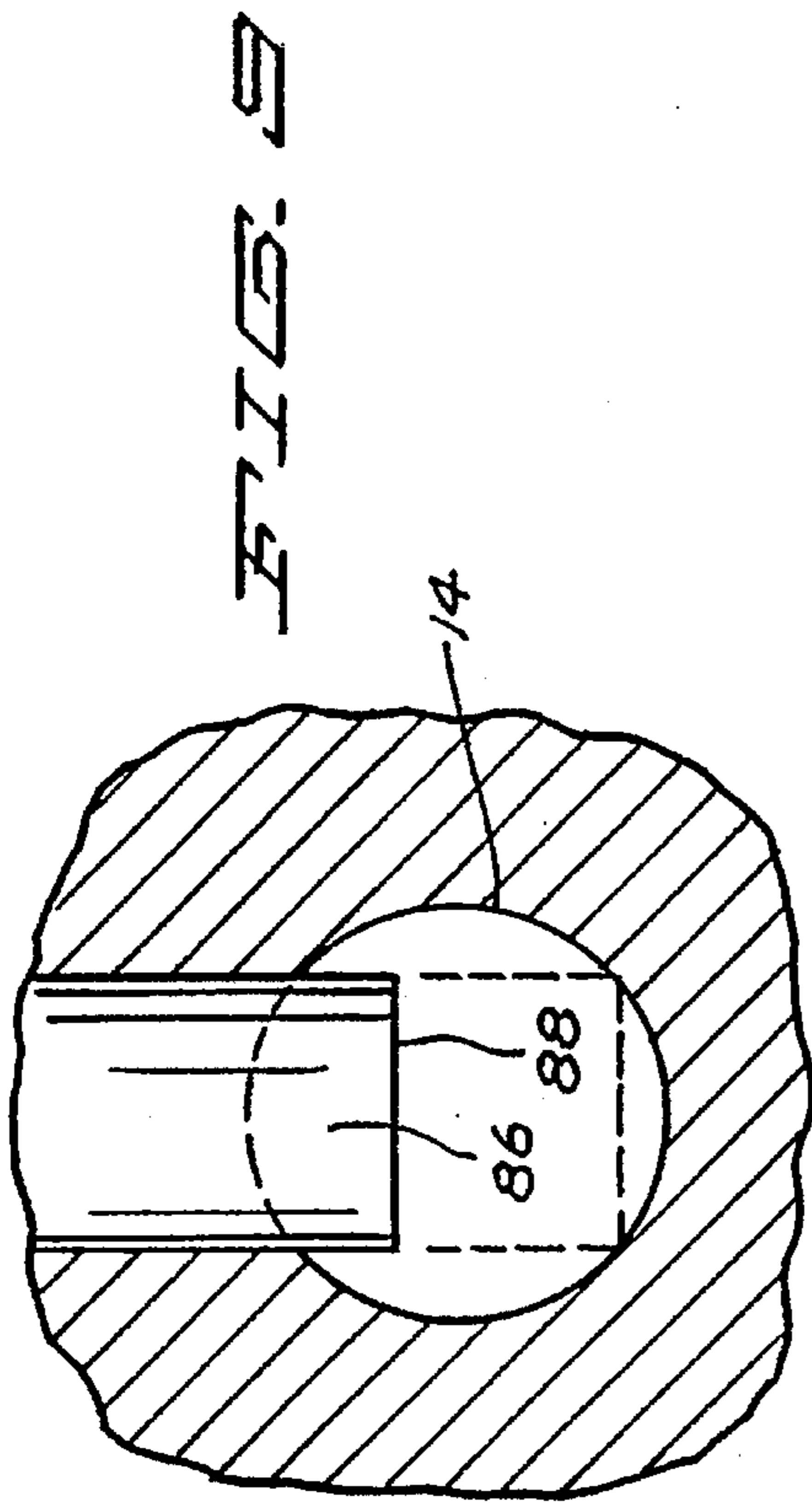
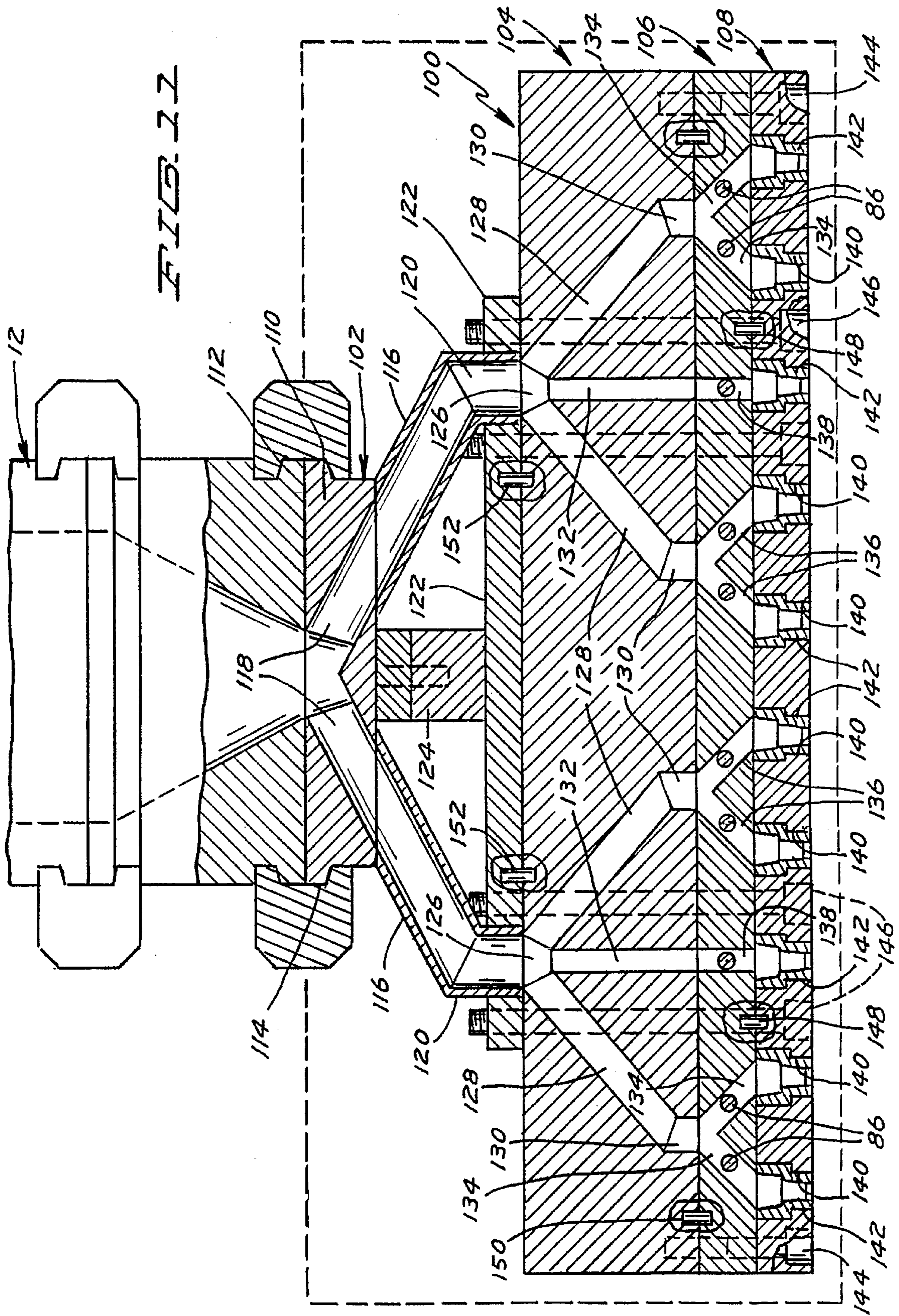


FIG. 4







APPARATUS FOR MAKING MULTIPLE, COMPLEXLY PATTERNED EXTRUDATES

CROSS REFERENCE

The present application is a continuation-in-part of U.S. patent application Ser. No. 08/241,321 filed May 11, 1994.

1. FIELD OF THE INVENTION

The present invention comprises apparatus and methods for making complexly patterned multicolored extruded food products. More particularly, the present invention relates to apparatus and methods for reducing a large cross sectional area complexly patterned food extrudate to a smaller area while maintaining the complex pattern, to apparatus and methods for adjusting flow of plastic extrudable food product, and to a manifold for making multiple extrudates formed of plastic extrudable food product and having uniformity of flow.

2. BACKGROUND

Food products such as Ready-To-Eat ("R-T-E") cereals and snack products vary widely in composition, shape, color, flavor, texture, etc. Such products can include both puffed and unpuffed varieties. One attractive feature is their appearance which can include specific attributes such as shape and coloration. Especially attractive are products having a complex but organized pattern of coloration, shape and/or complex shape.

A wide variety of techniques are known to provide complexly shaped products such as rings, stars, letters, figures, etc. Problems generally include how to provide consistently the desired degree of shape detail or resolution in the finished pieces. Similarly, for colored products, a problem is how to consistently provide a fine level of detail. This problem of imparting a fine level of detail is particularly difficult in the provision of complexly patterned R-T-E cereals due to their generally smaller size. The problem is even more severe for puffed R-T-E cereal products due to the very tiny size of the pellets that are expanded to form the finished products. Of course, the pellets must contain and retain the complex pattern.

In particular, it would be desirable to prepare puffed R-T-E cereals having a shape and color pattern reminiscent of various sports balls such as baseballs, footballs, basketballs and soccer balls, such as are disclosed in 1) U.S. patent application Ser. No. 014,233, filed Oct. 18, 1993 by Laughlin et al. entitled Food Product Piece, now U.S. Pat. No. Des 373,671, 2) 014,068, filed Oct. 12, 1993 by Laughlin entitled Food Product Piece, 3) U.S. patent application Ser. No. 014,474, filed Oct. 22, 1993 by Laughlin entitled Food Product Piece, now U.S. Pat. No. Des 368,791 issued Apr. 16, 1996 and 4) U.S. patent application Ser. No. 014,069, filed Oct. 12, 1993 by Laughlin entitled Food Product Piece, now U.S. Pat. No. Des 372,352 respectively, each of which are incorporated herein by reference. Such products are characterized in part by high degrees of resolution such as by line features (such as to indicate traditional sticking patterns) 1 mm> in thickness and even 0.5 mm>. Providing a cereal pellet which upon puffing provides a puffed R-T-E cereal exhibiting such a fineness of detail is a difficult problem to overcome.

Line colored or externally striped food products such as R-T-E cereals as well as apparatus and methods for their preparation are described in U.S. Pat. No. 2,858,217 entitled Cereal Product With Striped Effect and Method of Making

Same (issued Oct. 28, 1958 to J. O. Benson) and which is incorporated herein by reference. The '217 patent describes an extrudate extruder having a color injecting die insert for making a complexly patterned extrudate. However, the extrudate is directly extruded without any reduction in its cross sectional area. Also, the method appears to be limited to producing only flakes in a simple pattern of generally parallel more or less straight lines. The method is not capable of generating a direct expanded cereal or snack (i.e., expanded directly from the extruder) having a line detail of such a degree of fineness.

An improvement or modification in the technique for providing a line colored cereal based snack piece is described in U.S. Pat. No. 3,447,931 (issued Jun. 3, 1969 also to Benson et al.) entitled Process For Preparing a Puffed, Concave Shaped Cereal Product. More particularly, the '931 patent describes a process for making a cup flower shaped R-T-E cereal piece having a complex line pattern. The process involves extruding a plurality of rope dough filaments which are pressed together to form a column or rope without a material decrease in the cross section which is then combined under conditions such that no puffing occurs. The composite strand of compressed filaments is then cut into wafers and which are subsequently heat puffed. While useful, the process appears to be limited to producing only the "flower bloom" shape. Also, the pieces prepared are of a larger snack piece size rather than the relatively smaller pieces characteristic of R-T-E cereals.

Especially in commercial applications, the plastic extrudable food product is supplied in an amount to form a plurality of extrudates. Problems then arise that extrudates have uniformity of flow for consistency in the final product, with adjustment of the flow rate and pressure being accomplished without increasing the likelihood of downstream plugging. Furthermore, problems also arise that the extrudates interfere with each other such as by falling on top of each other thereby making downstream processing difficult.

In a first aspect, the present invention provides an improvement in apparatus and methods for preparing food products characterized by at least two colors in an organized pattern. In particular, the present invention provides an improvement in the degree of fineness level of color detail (1 mm>) even on food products such as pellets for puffed R-T-E cereals that are very small (e.g., 3 to 6 mm) in diameter.

In a further aspect, the present invention provides a flow rate adjustment apparatus for adjustment of plastic extrudable food flow. In particular, the present invention provides an improvement that the flow of dough is not stopped or allowed to build up which can lead to hardening of the dough, with hardened dough potentially causing plugging problems downstream.

In another aspect, the present invention provides a manifold where the extrudates are located in a non-circular pattern avoiding the problems of individual extrudates interfering with each other and allowing easier placement on horizontally arranged conveyors. In particular, the present invention provides an improvement that the extrudates are in a horizontal pattern in a single plane.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an end view partially cut away of the die face of a food cooker extruder showing a plurality of exit ports.

FIG. 2 is a sectional view greatly cut away of a reduction passageway of the present invention taken along lines 2—2 of FIG. 1.

FIG. 3 shows an enlarged sectional view of a die insert for making an enlarged complexly shaped dough taken along lines 3—3 of FIG. 2.

FIG. 4 is an enlarged sectional view of a die insert showing the channels for the food color flow taken along lines 4—4 of FIG. 3.

FIG. 5 is an enlarged sectional view of the die insert taken along lines 5—5 of FIG. 4 in an upstream orientation.

FIG. 6 is an enlarged sectional view of the die insert taken along lines 5—5 of FIG. 4 similar to FIG. 5 but showing a downstream orientation.

FIG. 7 is an enlarged plan view of a finished puffed complexly patterned R-T-E cereal piece prepared using the present methods and apparatus.

FIG. 8 is an enlarged sectional view of the R-T-E cereal piece taken along lines 8—8 of FIG. 7 showing the concave shape of the cereal piece.

FIG. 9 is a partial sectional view of the food cooker extruder taken along lines 9—9 of FIG. 2.

FIG. 10 is a front elevational view of a manifold for making multiple extrudates secured to the outlet of a food cooker extruder.

FIG. 11 is a partial cross-sectional view of the manifold taken along lines 11—11 of FIG. 10.

Where used in the various figures of the drawing, the same numerals designate the same or similar parts. Furthermore, when the terms "top," "bottom," "first," "second," "upper," "lower," "height," "width," "length," "end," "side," "horizontal," "vertical," and similar terms are used herein, it should be understood that these terms have reference only to the structure shown in the drawing and are utilized only to facilitate describing the invention.

DESCRIPTION

Referring now to the drawing and briefly in particular to FIG. 1, there is shown an apparatus for preparing a complexly patterned cereal dough piece according to the preferred teachings of the present invention that is generally designated 10. In the most preferred form, apparatus 10 generally includes a means for providing at least one extrudable food product or cooked cereal dough such as a cooker extruder 12 as seen in FIG. 1. Extruder 12 is seen to have at least one, and more preferably a plurality of, exit ports or orifices 13 each for extruding of a complexly patterned cooked cereal dough of the present invention (not shown) or other extrudable food product.

While a cooker extruder is the preferred equipment to provide the extrudable food, other conventional equipment and techniques can also be employed. For example, a batch cooker or semi-continuous cooker for cooking the ingredients in bulk can be equipped with dough forming and conveying extruder element. In other embodiments, e.g., a low moisture fruit paste, a simple screw conveyor can be employed. While in the present description particular reference is made to the provision of complexly patterned farinaceous materials such as R-T-E cereals and snack products, the skilled artisan will appreciate that the apparatus and techniques can be employed with a wide variety of extrudable food products, especially such plastic foods as low moisture fruit products.

Now referring to FIG. 2, the cooker extruder 12 provides the cooked cereal dough in quantity which can supply one or preferably, especially in commercial applications, a plurality of passageways 14, each leading to an exit port 13. In highly preferred embodiments, the apparatus 10 can additionally

include a means for adjusting the cooked cereal dough flow rate and pressure such as the adjustably retractable dough flow adjuster plug 16 depicted. Such a flow rate adjustment means is particularly useful when, as in the embodiment depicted, the extruder supplies a large number of extrudate orifices. Absent such a flow rate adjustment means, the particular extrudate characteristics (e.g., pressure, mass flow) from each of so many orifices are difficult to control since the length of passageway 14 from the central supply can vary.

Flow adjuster plug 16 can include a rod or bolt 80 having at least upper and lower cylindrical portions 84 and 86. Upper portion 84 in the most preferred form includes threads 82. Lower cylindrical portion 86 is in the most preferred form of a plug having a smooth outer periphery of a diameter which is less than the diameter of passageway 14. Further, the inner axial end 88 of portion 86 opposite to portion 84 has a generally flat configuration. Extruder 12 has a cylindrical bore which intersects generally perpendicular with passageway 14 and which includes a radially outward, threaded portion and a radially inward, smooth portion having a diameter generally equal to and for slideable and rotatable receipt of portion 86 such that the center line of portion 86 is generally perpendicular to the center line of passageway 14. Bolt 80 further includes a threaded portion located intermediate portions 84 and 86 of a size for threadable receipt in the extruder bore. Plug 16 further includes a means for sealing against dough of extruder 12 leaking from passageway 14 such as at least a first "O" ring 90, 91 inset into a receiving peripheral seal groove 92, 93, respectively. Plug 16 can further include lock nut 94 threaded on threads 82 of portion 84 and which can be tightened against block 96 to secure bolt 80 against movement such as caused by vibration of extruder 12.

By rotating bolt 80 into or out of the extruder bore, portion 86 can be adjustably retractably extended into passageway 14. It can then be appreciated that the area of flow through passageway 14 at plug 16 is inversely related to the extent that portion 86 extends into passageway 14. It should be appreciated that portion 86 can not choke or stop dough flow through passageway 14 or provide a buildup location for dough in passageway 14. In particular, due to the smaller diameter of portion 86 than passageway 14, the outer extent of portion 86 will extend along a chord of the circular cross section of passageway 14 at a spacing from its center less than its radius allowing flow of dough therebetween. It should be appreciated that due to the circular cross sections of portion 86, dough will tend to flow around portion 86 through passageway 14 and not stop in front thereof such as can occur if a flat or other non-cylindrical surface were presented. Likewise, when portion 86 is fully retracted out of passageway 14, the extruder bore does not form locations outside of passageway 14 in which dough can accumulate. Further, due to the preferred shape of end 88 relative to passageway 14, even if bolt 80 were rotated such that end 88 engaged the wall in extruder 12 defining passageway 14, end 88 does not closely mate passageway 14 but will similarly generally extend along a chord of the circular cross section of passageway 14 at a spacing from its center less than its radius allowing flow of dough therebetween. Stopping dough flow or allowing dough buildup or accumulation can lead to hardening of the dough, with hardened dough potentially causing plugging problems downstream. In the most preferred form, with end 88 engaging the wall in extruder 12 defining passageway 14, portion 86 covers less than 90% of the cross-sectional area of passageway 14 allowing flow of dough through at least 10% of the cross-sectional area of passageway 14 at all times.

The apparatus 10 further essentially includes at least one food color supply 18 which can supply a flowable colored food material such as food color liquid (whether oil or preferably water based). The color supply 18 is in fluid communication with and the apparatus 10 further includes a means for mixing or forming the food color liquid and extrudable food product into a complexly patterned food extrudate such as a greatly enlarged (relative to the exit orifice) pattern forming die insert 20 depicted. In the preferred embodiment, the passageway 14 can include a first flared or divergent portion 21 immediately upstream of the die insert 20 to widen the passageway 14 to an equal diameter to the die insert 20 as well as a second convergent flared portion 22 downstream. In the drawing, the passageway 14 and other constituent elements are depicted in close to actual size. Thus, the diameter of the die insert 20 is about 30 mm and is positioned within a slightly enlarged portion 24 of passageway 14. As a result, the diameter of the complexly patterned dough extrudate as it exits the die insert 20 will have an enlarged initial diameter about 30 mm. Of course, other sizes for the die insert 20 can be used (e.g., 15 to 100 mm).

In FIG. 2, it can be seen that the complexly patterned dough extrudate so formed then moves through by pressure flow and apparatus 10 further includes a means for reducing the cross sectional area of the complexly patterned food extrudate while maintaining the pattern such as a reducing or necking passageway 25 depicted. The reducing passageway 25 can be fabricated from a single piece having, for example, a frusto conical bore or, as depicted, with a plurality of individual pieces such as the first, second, and third pieces 26, 28 and 30, respectively, depicted. Individual pieces can be more easily cleaned. Also, the convergence angle and other attributes, e.g., internal surface, can be adjusted as needed (e.g., smoothness, anti-stick surface) to accommodate differences in the extrudate characteristics of different food products. In FIG. 2, it is seen that the passageway 14 has an initial relatively larger diameter 34 and a final relatively smaller or exit diameter 36 at the exit port 13. Moreover, while the passageway 14 is depicted as having a circular cross sectional area, in other embodiments the passageway 14 can be fabricated with a more complex pattern or peripheral configuration to define or define in part the exterior shape or configuration of the finished piece, including both regular shapes (e.g., stars, rings, ovoids, geometric shapes) as well as irregular shapes (e.g., animals, objects such as trees, cars, etc.). Furthermore, the passageway 14 can be fabricated with an interior surface of desired characteristics, e.g., polished or Teflon or other non-sticking surface, such as to provide decreased friction to facilitate retention of the complex pattern or to reduce the pattern's deformation. Especially desirable is an ovoid cross section for the passageway for preparation of an American style football or a rugby ball.

An important feature of the present invention is the convergence angle of the reducing passageway 25. It has been found important to maintain an average convergence or confinement angle of 5° to 45°, preferably 5° to 20°, and most preferably 10° to 15° in order to maintain the pattern while the cross sectional area is reduced. By "average convergence" is meant the angle formed from the diameter of the die insert 20 to the diameter 36 of exit port 13 over the length of the reducing passageway 25. As depicted, with passageway pieces 26, 28, and 30, some pieces, e.g., 26 and 30, have a sharper convergence angle while piece 28 has a shallower angle. Internal obstructions (e.g., shoulders) are to be avoided so as to provide a continuous passageway to

minimize disrupting the complex pattern formed in the dough. FIG. 2 shows that the exit orifice diameter 36 is about 3 mm. Since the passageway 14 can have a complex cross sectional shape as described above, the extent of reduction of the pattern is more aptly characterized in terms of cross sectional area reduction rather than more simply a reduction in diameter. Thus the degree of reduction of cross sectional area in the illustrated embodiment is about 100:1. Of course, for other embodiments (e.g., for larger snack pieces), the extent of cross section reduction can be as little as 25:1. The exit orifice diameter 36 for a snack product can be correspondingly larger, e.g., 5 to 15 mm.

Surprisingly, such a shallow convergence angle allows for a reduction in cross sectional areas of at least 50:1 and even about 100:1 while maintaining a fine level of detail in the complex pattern. Thus, a complex shape can be imparted to a larger dough face or cross section and then reduced to the much smaller desired finish cross sectional area. This arrangement allows for the fabrication of a relatively large die insert to impart the complex pattern. Fabricating a small die insert to impart the desired degree of detail for the final exit diameter while possible on a development scale extruder is not commercially practical due in part to plugging or fouling of the die insert 20. The provision of a reducing passageway 25 having the requisite convergence angle allows for the provision of three dimensional shapes to be produced with a fine level of color detail. Moreover, the finished pieces are characterized by a color through the entire piece as compared to only topical coloration.

Also, it is seen that the mixing is not immediately proximate the discharge port 13 but distanced therefrom. This allows for the dough to modestly "set" so as to assist in maintaining the complex shape.

Reference is now made to FIG. 3 which shows enlarged cross section of the pattern forming die insert 20. As can be seen, this particular die insert can be used to fabricate a bicolored food piece 40 as seen in FIG. 7 having a swirl or spiral pattern. However, other pattern forming die inserts can be substituted therefor which, for example, can impart the line pattern for products reminiscent of soccer balls, basketballs, baseballs, and other sports objects.

The die insert 20 includes a means for imparting at least one, and more desirably a plurality of, dough interstitial gaps such as a plurality of dough dividing passageways such as passageways 44, 45, and 46 respectively formed by die dividing members. The die insert 20 can further include a means for injecting a food color or second colored dough into the interstitial dough gaps such as a plurality or array of evenly spaced food color injection ports 48 fed by a fluid supplying passageway 50 therethrough. The extrudable food product itself may be colored. The color supply 18 may supply a different color or the same color having a darker or lighter hue. Specifically, the food color passageways 50 are supplied with the food liquid from one or more food color supply ports such as ports 52, 54, and 56, respectively in the die dividing members. Of course, when the second or colored material is a food product such as a second dough or fruit paste, the passageways and injection ports can be enlarged to reduce friction and the potential for blockage.

Referring now briefly to FIG. 4, it can be seen that the die insert 20 can further include a color fluid supply reservoir 58 supplied by the color supply 18 and which is in fluid communication with or supplies food color supply ports 52, 54, and 56. The die insert 20 can further include a means for sealing the color fluid supply reservoir 58 against premature admixture with dough such as "O" rings 60 and 62 depicted.

Reference is now briefly made to FIG. 5 which shows the upstream face 64 of the die insert 22. FIG. 5 shows that the upstream face 64 for this particular die insert contains no color supply discharge ports and that the discharge of color is preferably in a downstream direction.

Reference is now made briefly to FIG. 6 wherein the relationship between the supply inlet ports 52, 54, and 56, supply passageways 50 and color discharge ports 48 can be most simply seen.

Reference now is next briefly made to FIGS. 7 and 8 which show that the food piece 40 can have a cupped shape and that the coloration can extend throughout the body of the piece. The piece 40 depicted is a puffed R-T-E cereal piece prepared by direct expansion from the extruder having a finished diameter of about 70 mm.

In the present invention, the complexly patterned dough of reduced cross sectional diameter is extruded through the reduced diameter exit orifice 36 (e.g., about 3 mm). Thereafter, the extrudate is face cut in a conventional manner to form individual pieces such as with one or more rotating knives. Depending upon the conditions of the extrudate, an unpuffed pellet piece can be formed for subsequent puffing, or, alternatively, and preferably herein, a directly expanded finished puffed piece is formed. The finished food piece whether subsequently puffed or puffed by direct expansion upon exiting the exit orifice 13 is essentially characterized by exhibiting a high resolution or fine degree of color detail. The detail can include surface line coloration of as thin as about 0.5 mm in the puffed product. In certain embodiments, the interior is also bicolored or multicolored as well as having topical or surface coloration.

The extrudable food can comprise a wide variety of conventional food types and in particular can include a fruit paste, potato dough (e.g., for a fabricated chip) or a cooked cereal dough. The cooked cereal dough can be for either R-T-E cereals (whether puffed or unpuffed), snack products, baked goods, or pastas. Especially desirable are cooked cereal doughs for puffed R-T-E cereals. Puffed food products such as snacks can be prepared by hot air puffing, deep fat frying, gun puffing or microwave (especially high intensity, e.g., >100 V/cm field strength). Product puffed without deep fat frying can have oil added to the composition or have a topical oil application. R-T-E cereals can have a sugar coating. Puffed food pieces of the product base (i.e., prior to or without oil or sugar) can have a density of about 0.1 to 0.5 g/cc. The colored portion forms a line or a plane through the body of the food piece. "Highly complex" food products are characterized as having a plurality of colored features at least two of which (e.g., two planes or a line and a plane) intersect within the body of the food piece.

While in the present invention, the particular die insert 20 depicted is designed to admix a liquid food color into a cooked cereal dough so as to provide line coloration of extremely fine detail, the die insert 20 can be modified (e.g., such as by enlargement of ports 52, 54, and 56, fluid passageways 50, and discharge ports 48) to admix two or more cooked doughs or other flowable colored food materials, especially liquefied fats (e.g., chocolate, cheese), or fruit paste.

Also, while the particular die insert 20 depicted is designed to provide the swirled finished product depicted, other die inserts can be interchanged to provide the line coloration detail to provide the particular desired end products such as the various sports balls (e.g., soccer, baseball, basketball, American football) referenced above.

It will be appreciated that for those embodiments that are extruded without direct expansion or puffing upon extrusion

that lines having a detail of about 0.1 mm in width can be obtained. Upon subsequent expansion (e.g., deep fat frying, gun puffing, fluidized bed puffing, radiant heat puffing or other puffing methods), puffed pieces will of course expand causing an increase in the width of the line. These enlarged lines (i.e., 0.5 mm >), however, are nonetheless thinner than lines obtainable by any other known method. If desired, thicker lines (e.g., about 3 mm) can also be formed.

Other dough flow adjustment devices can be used with or in substitution for the preferred flow adjuster plug 16 herein if 1) positioned upstream of the die insert 20, and 2) do not increase the likelihood of downstream plugging. For example, and referring to FIGS. 10 and 11, an alternate embodiment of a dough manifold 100 is shown according to preferred teachings of the present invention. In particular, manifold 100 includes body portions 102, 104, 106 and 108 which are secured together into a unitary assembly. In particular, body portion 102 includes a circular disc 110 which abuts with the mounting flange 112 of the outlet of food cooker extruder 12. Disc 110 can be secured to extruder 12 by any conventional means and in the preferred form includes an annular lip 114 formed on its outer periphery at the inner axial end which abuts with flange 112, with lip 114 being of a size and shape generally corresponding to flange 112.

Bores or conduit portions 118 intersect at the inner axial end of disc 110 at the center line of extruder 12 and disc 110 and extend therefrom at equal acute angles on opposite sides of the center line of extruder 12 and disc 110 in the order of 62° in the most preferred form, with the center lines of bores 118 and the center line of extruder 12 and disc 110 being arranged in a horizontal plane in the most preferred form.

Body portion 102 further includes first and second pipes or conduit portions 116 which extend linearly from bores 118 formed in disc 110 past the outer axial end of disc 110 to equal distances from disc 110.

Body portion 102 further includes first and second conduit portions 120 located on opposite sides, parallel to, and at equal distances from the center line of extruder 12 and disc 110, with the center lines of conduit portions 120, extruder 12 and disc 110 being arranged in a horizontal plane in the most preferred form. Conduit portions 120 have cross sections of an equal size and shape to pipes 116. The outer axial ends of first and second pipes 116 opposite to disc 110 are integrally connected to and in fluid communication with the inner axial ends of first and second conduit portions 120, respectively, in the most preferred form by a mitered interconnection. The outer axial ends of conduit portions 120 are equally spaced from disc 110 and extruder 12.

Body portion 102 further includes a flat mounting plate 122 which is held generally perpendicular to the center lines of conduit portions 120, extruder 12 and disc 110 by a support 124 extending between and integrally connected to the outer axial end of disc 110 and the inner axial end of plate 122. Conduit portions 120 extend through suitable bores formed in mounting plate 122 and are integrally secured to mounting plate 122. The outer axial end of mounting plate 122 is perpendicular to the center lines of conduit portions 120, disc 110, and extruder 12 and is at the same axial extent from disc 110 and extruder 12 as the outer axial ends of conduit portions 120.

Body portion 104 is in the most preferred form of a block having an inner axial end which abuts with mounting plate 122. Body portion 104 is symmetrical on opposite sides of the center line of disc 110 and extruder 12 according to preferred teachings of the present invention. In particular,

body portion 104 includes first and second conical chambers 126 having center lines which are linear with the center lines of conduit portions 120. The bases of chambers 126 are located at the inner axial end of body portion 104 and have a diameter equal to the inner diameter of conduit portions 120.

First and second passageway portions 128 of equal size and diameter extend from each of chambers 126 at equal acute angles on opposite sides of the center line of chamber 126 and conduit portion 120 in the order of 49° in the most preferred form, with the center lines of passageway portions 128, chambers 126, conduit portions 120, bores 118, pipes 116 and extruder 12 being arranged in a horizontal plane in the most preferred form. Body portion 104 further includes third and fourth passageway portions 130 in fluid communication with first and second passageways 128, respectively, and located on opposite sides, parallel to and at equal distances from the center lines of the first and second chambers 126 and conduit portions 120, respectively, with the center lines of passageway portions 128 and 130 being in a horizontal plane in the most preferred form. Passageway portions 128 and 130 have cross sections of an equal size and shape and in the most preferred form have diameters which are approximately 57% of the diameter of conduit portions 116, 118, and 120.

Body portion 104 further includes first and second duct portions 132 having center lines which are coextensive with the center lines of the first and second chambers 126 and conduit portions 120, respectively, with duct portions 132 extending from chambers 126 concentric to the center line of chambers 126 and opposite to their bases. In the most preferred form, duct portions 132 have a cross-sectional shape corresponding to passageway portions 128 and 130 which is circular in the most preferred form but have a size which is smaller than passageway portions 128 and 130 and in the most preferred form have diameters equal to approximately 65% of the diameter of passageway portions 128 and 130. In the most preferred form, duct portions 132 have a size which do not intersect with passageway portions 128 at chamber 126, with duct portions 132 having a diameter equal to the diameter of chambers 126 equal to the outer axial extent of passageway portions 128 at the surfaces of chambers 126 in the most preferred form.

Body portion 106 is in the most preferred form of a block having an inner axial end which abuts with the outer axial end of body portion 104. Body portion 106 is symmetrical on opposite sides of the center line of disc 110 and extruder 12 according to the teachings of the present invention. In particular, first and second ports 134 of equal size and diameter extend from the first passageway portions 130 extending from first and second chambers 126 at equal acute angles on opposite sides of the center line of first passageway portion 130 in the order of 43° in the most preferred form, with the center lines of ports 134 and passageway portions 130 being arranged in a horizontal plane in the most preferred form. Further, third and fourth ports 136 of equal size and diameter extend from the second passageway portion 130 extending from first and second chambers 126 at equal acute angles on opposite sides of the center line of second passageway portion 130 in the order of 43° in the most preferred form, with the center lines of ports 136 and passageway portions 130 being arranged in a horizontal plane in the most preferred form. Ports 134 and 136 have equal lengths. Body portion 106 further includes first and second duct portions 138 having center lines which are coextensive with the center lines of first and second duct portions 132 and chambers 126 of body portion 104 and of

conduit portions 120, respectively. Duct portions 138 have a cross-sectional size and shape corresponding to duct portions 132. Ports 134 and 136 have the same cross-sectional size and shape which in the preferred form also are equal to the cross-sectional size and shape of duct portions 132 and 138.

Body portion 106 according to the preferred teachings of the present invention then includes a plurality of flow adjuster plugs 16 of a number corresponding to the total number of ports 134 and 136 and duct portions 138 formed therein and mounted to the upper surface thereof. In particular, plugs 16 are mounted such that smooth portion 86 can be adjustably extended into the corresponding port 134 or 136 or duct portion 138 to adjust the flow rate and pressure of the dough flow therethrough.

Body portion 108 is in the most preferred form of a block having an inner axial end which abuts with the outer axial end of body portion 106. Body portion 108 is symmetrical on opposite axial sides of the center line of disc 110 and extruder 12 according to the teachings of the present invention. In particular, sockets 140 equal in number and location to ports 134 and 136 and duct portion 138 are provided for slideable receipt of the desired inserts 142. It can be appreciated that inserts 142 can be of the type including die inserts 20 and passageway pieces 26, 28, and 30 or can be of alternate types and forms.

Body portions 102, 104, 106, 108 can then be suitably secured together such as by bolts 144 extending through body portions 108 and 106 and threaded into body portion 104 and by bolts 146 extending through body portions 108, 106, and 104 and threaded into mounting plate 122. To insure proper alignment and for ease of assembly, dowel pins 148, 150, and 152 can be provided between body portions 108 and 106, body portions 106 and 104, and body portion 104 and mounting plate 122, respectively.

In operation of manifold 100 according to the teachings of the present invention, dough extruded by extruder 12 will flow through flow paths at equal rates and pressure through conduits 116, 118, and 120 into chamber 126 since they provide the same resistance to flow due to their equal lengths, cross-sectional sizes and shapes, and arrangement much like through passageways 14. Likewise, dough will flow through passageways 128 and 130 from chambers 126 at equal rates and pressure since they provide the same resistance to flow due to their equal lengths, cross-sectional size and shape, and arrangement. Similarly dough will flow through ports 134 and 136 from passageways 128 and 130 at equal rates and pressure since they provide the same resistance to flow due to their equal lengths, cross-sectional size and shape, and arrangement. However, since ducts 132 and 138 have a smaller cross-sectional size than passageways 128 and 130, the flow rate of dough through a single duct 132 and 138 is one-half the flow rate through one of ports 134 and 136. In particular, due to the much shorter length that the dough must flow to reach die inserts 142 through one duct 132 and 138, the cross-sectional size is reduced to a size to provide equal flow resistance there-through as through dough flowing through one of the ports 134 and 136. Further, according to the preferred teachings of the present invention, the cross-sectional size of ports 134 and 136 and ducts 132 and 138 are equal for ease of fabrication and to allow the same size adjuster plugs 16 to be utilized in all of the ports 134 and 136 and duct portions 138.

It can then be appreciated that the flow rate and pressure from extruder 12 to inserts 142 are equal even though the

flow distances from extruder 12 to inserts 142 are not equal according to the teachings of the present invention. Specifically, the flow rate and pressure to inserts 142 are generally compensated by providing unequal flow areas to effect equalizing flow resistance and are fine tuned through the use of adjuster plugs 16 according to the teachings of the present invention. Thus, utilizing the present invention, it is no longer required that the inserts 142 be located in a circular pattern centered on the center line of extruder 12 to obtain equal flow distances in symmetrical arrangements. Particularly, other patterns are possible according to the teachings of the present invention such as horizontal in a single plane which avoids problems of individual extrudates interfering with each other such as upper extrudates falling on lower extrudates in the circular pattern and which allows easier placement on horizontally arranged conveyors.

Thus since the invention disclosed herein may be embodied in other specific forms without departing from the spirit or general characteristics thereof, some of which forms have been indicated, the embodiments described herein are to be considered in all respects illustrative and not restrictive. The scope of the invention is to be indicated by the appended claims, rather than by the foregoing description, and all changes which come within the meaning the claims are equivalency of the claims are intended to be embraced therein.

We claim:

1. Manifold for making multiple extrudates formed from a food dough exiting from a source and having uniformity of flow, comprising, in combination: a plurality of exit orifices located at differing spacings from the source; and with each of the exit orifices including a flow path for the food dough from the source to the exit orifice, with the flow paths of at least two pair of the exit orifices being formed by at least first and second passageways and first, second, third, and fourth ports, with the first and second passageways extending downstream from an interconnection at a passageway angle relative to each other and having equal cross-sectional sizes and shapes, with the first and second passageways extending from the interconnection in a nonparallel manner, with the first and second ports extending downstream from the first passageway and having generally equal cross-sectional sizes and shapes and the third and fourth ports extending downstream from the second passageway and having generally equal cross-sectional sizes and shapes generally equal to the cross-sectional sizes and shapes of the first and second ports and less than the cross-sectional sizes of the first and second passageways, with the first and second passageways having generally equal lengths, with the first, second, third, and fourth ports having generally equal lengths, wherein the flow path of at least one of the exit orifices is formed by a duct having a constant size and extending downstream from the interconnection of the first and second passageways to the exit orifice, with the cross-sectional size of the duct being less than the cross-sectional size of the first and second passageways, with each of the flow paths including means for adjusting the rate and pressure of the flow of the dough.

2. The manifold of claim 1 wherein the adjusting means each comprise a plug extendable into the flow path.

3. The manifold of claim 2 wherein the cross sections of the port and the plug are circular and each include a center line, with the diameter of the plug being less than the diameter of the port, with the center line of the plug being at a non-parallel angle to the center line of the port.

4. The manifold of claim 2 wherein the adjusting means each further comprises, in combination: a bolt, with the plug formed on the bolt, with the bolt being threaded to extend or retract the plug into the port.

5. The manifold of claim 4 wherein the adjusting means each further comprises, in combination: a lock nut threaded on the bolt and which can be tightened to secure the bolt against movement.

6. The manifold of claim 1 wherein the duct has a cross-sectional size and shape generally equal to the cross-sectional size and shape of the first, second, third, and fourth ports.

7. The manifold of claim 6 wherein the interconnection of the first and second passageways comprises a conical chamber having a base and a center line, with the first and second passageways extending downstream from the conical chamber at equal, nonparallel angles to the center line of the conical chamber and on opposite sides of the center line of the conical chamber, with the duct extending downstream from the conical chamber concentric to the center line and opposite to the base.

8. The manifold of claim 7 wherein the first and second ports extend at a port angle on opposite sides of the first passageway and the third and fourth ports extend at the port angle on opposite sides of the second passageway.

9. The manifold of claim 1 wherein the plurality of exit orifices are located in a single, horizontal plane.

10. The manifold of claim 1 wherein the flow paths further comprise, in combination: first and second conduits extending at an angle relative to each other and having generally equal cross-sectional sizes and shapes and greater than the cross-sectional sizes of the first and second passageways, with the first and second conduits having generally equal lengths, with the first and second passageways extending downstream from the first conduit; third and fourth passageways extending downstream from the second conduit; and fifth, sixth, seventh, and eighth ports, with the fifth and sixth ports extending downstream from the third passageway and the seventh and eighth ports extending downstream from the fourth passageway.

11. The manifold of claim 10 wherein the source comprises an outlet including an annular mounting flange; and wherein the manifold further comprises a disc for abutting with and securement to the annular mounting flange, with the first and second conduits extending from bores formed in the disc, with the bores being in communication with the source.

12. The manifold of claim 11 further comprising, in combination: a mounting plate supported by the disc, with the conduits extending into and through the mounting plate; and a manifold block secured to the mounting plate, with the passageways and ports formed in the manifold block.

13. Manifold for making multiple extrudates formed from a food dough exiting from a source and having uniformity of flow, comprising, in combination: a plurality of exit orifices located at differing spacings from the source; and with each of the exit orifices including a flow path for the food dough from the source to the exit orifice, with the flow paths of at least two pair of the exit orifices being formed by at least first and second passageways and first, second, third, and fourth ports, with the first and second passageways extending downstream at a passageway angle relative to each other and having equal cross-sectional sizes and shapes, with the first and second ports extending downstream from the first passageway and having generally equal cross-sectional sizes and shapes and the third and fourth ports extending downstream from the second passageway and having generally equal cross-sectional sizes and shapes generally equal to the cross-sectional sizes and shapes of the first and second ports and less than the cross-sectional sizes of the first and second passageways, with the first and second passageways having

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generally equal lengths, with the first, second, third, and fourth ports having generally equal lengths; with each of the flow paths including means for adjusting the rate and pressure of the flow of the dough comprising a plug extendable into the flow path, with the cross sections of the port and the plug being circular and each including a center line, with the diameter of the cross sections of the plug being less than the diameter of the port; wherein the center line of the plug is perpendicular to the center line of the port; and wherein the plug has an axial end located inside of the port, with the axial end of the plug having a generally flat configuration which cannot closely mate with the port allowing flow of dough between the axial end of the plug and the port at all positions of the plug.

14. The manifold of claim 13 wherein the first and second passageways extend downstream from an interconnection; and wherein the flow path of at least one of the exit orifices is formed by a duct extending downstream from the interconnection of the first and second passageways and having a constant size to the exit orifice, with the cross-sectional size of the duct being less than the cross-sectional size of the first and second passageways.

15. The manifold of claim 14 wherein the duct has a cross-sectional size and shape generally equal to the cross-sectional size and shape of the first, second, third, and fourth ports.

16. The manifold of claim 13 wherein the flow paths further comprise, in combination: first and second conduits extending at an angle relative to each other and having

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generally equal cross-sectional sizes and shapes and greater than the cross-sectional sizes of the first and second passageways, with the first and second conduits having generally equal lengths, with the first and second passageways extending downstream from the first conduit; third and fourth passageways extending downstream from the second conduit; and fifth, sixth, seventh, and eighth ports, with the fifth and sixth ports extending downstream from the third passageway and the seventh and eighth ports extending downstream from the fourth passageway.

17. The manifold of claim 13 wherein the adjusting means each further comprises, in combination: a bolt, with the plug formed on and rotatable with the bolt, with the bolt being threaded to extend or retract the plug into the port.

18. The manifold of claim 17 wherein the adjusting means each further comprises, in combination: a lock nut threaded on the bolt and which can be tightened to secure the bolt against movement.

19. The manifold of claim 14 wherein the interconnection of the first and second passageways comprises a conical chamber having a base and a center line, with the first and second passageways extending downstream from the conical chamber at equal, nonparallel angles to the center line of the conical chamber and on opposite sides of the center line of the conical chamber, with the duct extending downstream from the conical chamber concentric to the center line and opposite to the base.

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